

Transhepatic anterior approach to the inferior vena cava in large retroperitoneal tumors resected en bloc with the right liver lobe

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Background. The operative approach to large retrohepatic tumors can be challenging because of the difficulty in exposing the inferior vena cava (IVC) and controlling bleeding. The anterior approach to the IVC associated with the hanging maneuver for liver transection, originally described in large hepatic tumors, may also facilitate removal of large masses set behind the liver.

Methods. A prospective cohort of 10 patients with large retrohepatic tumors involving the IVC was selected according to restrictive criteria (ie, single low-grade tumor, sufficient liver remnant, normal hepatic function, absence of cholestasis, and symptoms secondary to lower vena cava obstruction). In all cases, the anterior approach and the hanging maneuver were applied intentionally to expose the IVC without any liver mobilization. Depending on tumor invasiveness, either IVC-preserving (n = 7) or IVC-removing (n = 3) strategies were applied. Our aim was to assess the safety of the technique and the possible benefits for patient outcome.

Results. The cohort represented less than 1% of a series of 1,168 major hepatectomies performed in our unit between 2005 and 2011. The median age of the patients was 58; adrenal tumors and retroperitoneal sarcomas accounted for 70% of the series. Total vascular liver exclusion was necessary in 3 patients. Median operative time was 420 min. R0 resection was obtained in all cases, with no mortality and 40% overall morbidity. Overall survival was 83% at 5 years.

Conclusion. The transhepatic, anterior approach to the IVC is a safe procedure that improves vascular control, facilitates vein repair or reconstruction, and allows potentially curative resection of large retrohepatic tumors. This approach should be the preferred choice to be adopted in properly selected patients. (*Surgery* 2013;154:1061-8.)

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RETROHEPATIC TUMORS can be challenging to resect because of their proximity to or adhesion to the infrahepatic portion of the inferior vena cava (IVC), which puts any attempt at operative removal at high risk for uncontrollable bleeding. The crucial point during resection of such bulky masses

(primary, metastatic, or recurrent neoplasms) is the safe control of the IVC and hepatic veins because these tumors tend to push forward the posterior segments of the right lobe and impede liver mobilization, retrohepatic dissection, and the exposure of the short hepatic veins and IVC.

Various operative techniques have been described¹ concerning retrohepatic vascular control,^{2,3} from brief partial occlusion of the IVC wall up to total vascular exclusion of the liver with or without diversion of caval and/or portal flow, as in liver transplantation. In addition, should resection of the IVC be necessary due to tumoral infiltration, vein replacement has been described by means of autologous, cryopreserved allografts or prosthetic vascular grafts.⁴

An original alternative first described by Lai,⁵ Fan,^{6,7} and Belghiti,⁸ is represented by the anterior

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approach to the IVC. Through this access, facilitated by the liver hanging maneuver⁸ (a tape passed in front of the anterior wall of IVC and pulled upward during parenchymal transection), the avascular space along the anterior surface of retrohepatic IVC⁹ can be exposed with no need to mobilize the right lobe. In doing so, the IVC can be controlled to a large extent before any dissection of the retrohepatic tumor behind the liver; in fact, the tumor is mobilized in the final part of the operation en bloc with the detached right liver lobe.¹⁰

There is only one report describing the use of the anterior approach to the IVC for resection of large tumors of the right upper quadrant.¹¹ Herein, we add a cohort of patients with various grades of IVC involvement due to retrohepatic tumors in which stringent selection criteria were applied before adopting a deliberate, transhepatic anterior approach for resection, with the help of the liver hanging maneuver. In our experience, this technique used at the beginning of the operation, with no attempt to mobilize the liver from the retrohepatic space, has increased the operability, improved visualization for resection, and produced encouraging results in terms of patient outcomes.

METHODS

After the original description, the anterior approach to the IVC associated with minimal or absent liver mobilization has been adopted at the Hepato-Bilio-Pancreatic Surgery and Liver Transplant Unit of the National Cancer Institute of Milan in patients undergoing difficult hepatectomies for recurrent colorectal metastases involving the hepatodiaphragmatic structures. Since 2005, after having acquired sufficient experience, we began to apply the technique prospectively in selected patients referred for retrohepatic tumors, with or without involvement of posterior segments of the liver.

The principle of resection-related benefit guided our patient selection; in fact, the procedure was offered only to patients with the potential for prolonged survival. To be selected for tumor removal en bloc with an otherwise healthy right liver, patients with retrohepatic neoplasms had to show the following characteristics:

- (1) tumors had to be single and locally invasive, with no distant metastases;
- (2) preoperative hepatic volume via computed tomography (CT) or magnetic resonance imaging (MRI) (Myrian Software Suite, Intrasure, Montpellier, France) had to show a remnant liver-to-bodyweight ratio of at least 0.5¹² and to be 0.8 in case of severe steatosis and/or prolonged neoadjuvant chemotherapy containing irinotecan or oxaliplatin¹³;
- (3) coagulation profile and bilirubin had to be within normal range, with no signs of duct dilation in the remnant liver segments;
- (4) patients had to have a good performance status with no cancer-related symptoms (Eastern Cooperative Oncology Group [ECOG] 0 stage¹⁴) and no contraindications to major surgery (American Society of Anesthesiologists [ASA] physical status classification class 1-2)¹⁵;
- (5) absence of clinically detectable IVC syndrome (no lower limb edema, renal insufficiency, or enlarged retroperitoneal veins);
- (6) malignant histology of low-grade tumors at preadmission biopsy and formal discussion at the multidisciplinary tumor board had to be acquired. Poorly differentiated (grade 3 to 4) and rapidly progressing epithelial or sarcomatous malignancies were excluded.

All patients underwent postoperative thromboprophylaxis involving compression stockings, early mobilization, and perioperative subcutaneous low molecular weight heparin continued for 1 month postoperatively.¹⁶

Operative complications were graded according to the Dindo-Clavien classification.¹⁷ The institution's ethical committee agreed on the collection of a prospective cohort of 10 patients meeting the predetermined selection criteria and followed for at least 1 year. Our aim was to assess the safety of the technique as the primary endpoint for future use of the same approach in patients with retrohepatic tumors with similar eligibility criteria.

RESULTS

Of 1,168 open liver resections performed in our unit between 2005 and 2011, 157 major hepatectomies were conducted through the anterior approach. Among them, various kinds of resections and reconstructions of IVC or portal vein were applied in 28 patients (2.4%). Of the entire population, 10 patients (0.9%) fit the described entry criteria and were included in this prospective investigation.

During the first part of the operation, the right liver lobe was separated from the left along the Cantlie line,¹⁸ and the IVC was exposed intentionally via this anterior transhepatic approach. This approach facilitated subsequent mobilization and resection of large tumors arising behind the liver and adherent to the posterior segments and, therefore allowed, when needed, an en bloc resection

with the right hepatic lobe as well as adjacent organs, such as kidney, adrenal gland, diaphragm, or right inferior lobe of the lung. In all cases, the lateral or posterior surface of the IVC was partially or totally fused with the tumor, requiring various types of vascular resection and reconstruction.

The main characteristics of the patients, tumors, and operative techniques are summarized in the Table. The median age of the patients was 58 years, with median follow-up of 40 months. Of the 10 patients, 4 had primary right adrenal cortical tumors, and another had an adrenal metastasis from hepatocellular carcinoma. In the other 5 patients, 3 had sarcomas, 1 had renal cell cancer, and 1 had metastatic ovarian cancer. In 8 cases, the right diaphragm was partially resected and reconstructed, in 3 with an expanded polytetrafluoroethylene prosthesis (ePTFE) (Dual-mesh; Gore, Flagstaff, AZ) or sutured directly in 5 patients.

With respect to exposure, handling, and repair of the IVC, two fundamental strategies were followed, according to the presentation of the tumor: the IVC-preserving ($n = 7$) and the IVC-removing ($n = 3$) strategy, summarized in Figs 1 and 2, respectively. Whenever the tumor capsule allowed gentle separation of the posterior and/or lateral surfaces of the tumor from the IVC, the IVC-preserving strategy was pursued. Conversely, when invasion of the IVC was deemed possible, encirclement of the suprahepatic and infrahepatic vena cava with consequent preparation for total vascular exclusion was adopted. In the IVC-removing cases (cases 2, 6, and 8), the transhepatic approach was conducted until reaching the minimal interface between liver and tumor capsule. Then a gentle dissection proceeded toward the left border of the IVC; a plane was developed with the aim of preserving the caudate lobe and the remnant liver segments (I to IV) whenever possible. In such cases, the IVC was not separable from the tumor because the slow-growing neoplasm penetrated into the space of Coinaud, ie, the loose avascular space between the IVC and the posterior aspects of the liver.^{18,19} These 3 patients underwent resection and direct reconstruction of the entire IVC using an ePTFE graft of appropriate length (Gore-Tex vascular graft, Gore, Newark, NJ) under total vascular exclusion or IVC cross-clamp. In 2 cases, only the posterolateral wall of the cava was removed and repaired with a large, cryopreserved cadaveric vein patch (Fig 3). In all cases, the upper level of IVC clamping and reconstruction was below the confluence of the middle and left hepatic vein after the right hepatic vein was tied

at the confluence and retained in the en bloc specimen (including the tumor, the right liver, and the surrounding structures).

In all cases, parenchymal liver transection was facilitated by the liver hanging maneuver with the use of the ultrasonic dissector (CUSA; Cavitron Ultrasonic Surgical Aspirator, Valleylab, Boulder, CO) and irrigated monopolar or bipolar cautery (Aquamantys; Salient Surgical Technologies, Portsmouth, NH). Bleeding during the creation of the hanging maneuver occurred in patient number 1 (Table), when the bulky retroperitoneal tumor displaced the dissection plane from the avascular space on top of the IVC; the liver parenchyma was torn when developing this plane, with consequent bleeding from the hepatic vein branches.

The median operative time of the series was 420 min (range, 180 to 600). Intraoperative blood transfusions were required in half of the patients (median 750 mL of red blood cells, range, 0 to 13,500).

There was no postoperative mortality, and complications were generally mild (grade 1 and 2) but were severe (grade 3a and 3b) in 2 patients, respectively: one patient developed a partial abdominal wall dehiscence that required reoperation, and the other had a biliary fistula that required transhepatic percutaneous drainage. The median postoperative hospital stay was 12 days (range, 5 to 36), and overall survival was 83% at 5 years. Two patients of the series developed recurrence 30 months after operation, a third patient developed recurrence at 48 months, and a fourth patient developed a double recurrence of liposarcoma at 34 and 48 months after the operation; 3 of these 4 patients were re-resected and are currently alive and without disease, while the fourth patient died 3 years after the first operation.

At histology, surgical margins were negative in all patients; liver parenchyma was involved microscopically in 4 cases (40%), and the IVC wall was invaded in 3 patients, in whom the IVC-removing strategy was adopted. With respect to pathology-matched historical controls, the resectability rate of the present series of retroperitoneal tumors involving the right liver lobe and IVC was markedly improved. For similar tumor location and size, the resectability rate achieved through a conventional approach of right liver mobilization (12 patients operated on before 2005) was 36% vs 100% of the patients in this current series. For similar low-grade tumors undergoing conventional surgery associated with partial liver resection (37 patients in whom

Table. The National Cancer Institute – Milan cohort series of 10 large retrohepatic tumors removed after use of the transhepatic anterior approach and the liver hanging maneuver combined with IVC-preserving or IVC-removing strategy

<i>Pt</i>	<i>Diagnosis and tumor largest diameter</i>	<i>Organs resected</i>	<i>IVC strategy</i>	<i>IVC vascular control</i>	<i>IVC treatment</i>	<i>Liver/IVC infiltration</i>	<i>Margin status</i>	<i>Status</i>
1	Solitary fibrous tumor of the retroperitoneum (25 cm)	Right hemiliver, adrenal, diaphragm and inferior lung lobe	Preserving	TVE	Vein wall resection and direct suture	No/No	R0	Alive without disease at 33 months
2	Recurrent liposarcoma (20 cm)	Right hemiliver, adrenal and diaphragm	Removing	TVE	PTFE graft	No/Yes	R0	Alive without disease at 50 months (abdominal recurrences resected at 34 and 48 months)
3	Adrenocortical carcinoma (7 cm)	Right hemiliver, adrenal and diaphragm	Preserving	IVC cross-clamp	Vein wall resection and direct suture	No/No	R0	Alive without disease at 66 months (lung recurrence resected at 48 months)
4	Adrenocortical carcinoma (8 cm)	Right hemiliver, adrenal, and diaphragm	Preserving	IVC cross-clamp	Venous patch	Yes/No	R0	Alive without disease at 70 months (lung recurrence resected at 30 months)
5	HCC adrenal metastases (6 cm)	Right hemiliver, adrenal and diaphragm	Preserving	None	Vein wall resection and direct suture	Yes/No	R0	Alive without disease at 87 months
6	Adrenocortical carcinoma (8 cm)	Right hemiliver, kidney, adrenal, and diaphragm	Removing	TVE	PTFE graft	No/Yes	R0	Dead due to recurrence at 36 months (lung metastases at 30 months)
7	Ovarian cancer metastases (13 cm)	Right hemiliver, adrenal and diaphragm	Preserving	None	None	No/No	R0	Alive without disease at 12 months
8	Renal cancer (28 cm)	Right hemiliver, kidney and adrenal	Removing	IVC cross-clamp	PTFE graft	Yes/Yes	R0	Alive without disease at 11 months
9	Adrenocortical carcinoma (7 cm)	Right hemiliver, kidney and adrenal	Preserving	IVC cross-clamp	Venous patch	Yes/No	R0	Alive without disease at 22 months
10	Liposarcoma (9 cm)	Right hemiliver, adrenal and diaphragm	Preserving	None	None	No/No	R0	Alive without disease at 40 months

FFP, Fresh frozen plasma; *IVC*, inferior vena cava; *PTFE*, polytetrafluoroethylene; *RBC*, red blood cells; *TVE*, total vascular exclusion.

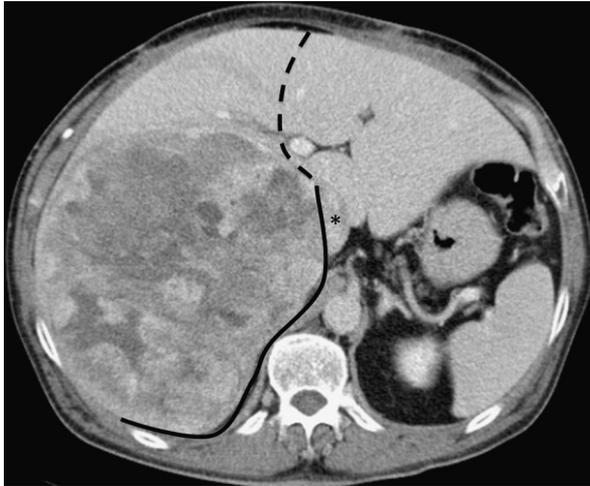


Fig 1. The IVC-preserving strategy. The IVC is exposed via the anterior trans-hepatic approach in two steps. When the IVC (*) is severely compressed but not infiltrated, an IVC-preserving strategy is appropriate. After right hepatectomy (*dotted line*), careful mobilization of the tumor mass along with the diaphragm can be carried out (*continuous line*), allowing preservation of the IVC. (Patient #1; patient alive and well 33 months after the operation). IVC, Inferior vena cava.

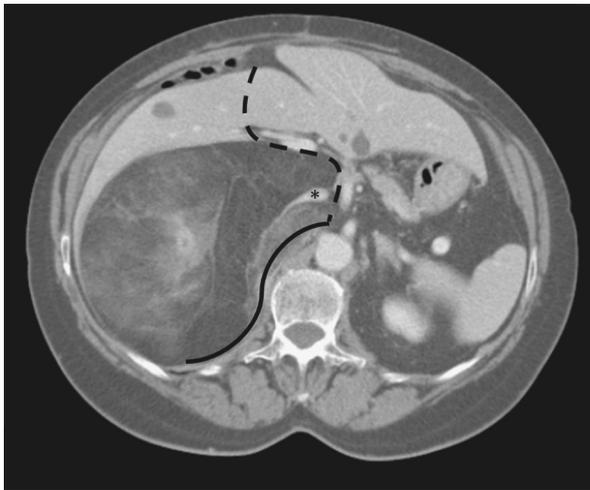


Fig 2. The IVC-removing strategy. The anterior approach through the Cantlie line can be conducted from the liver surface to the tumor capsule (*dotted line*) and then continued to the left of the IVC and down toward the aorta (*continuous line*). For tumors encircling the IVC for more than 180 degrees, the IVC can be removed en bloc with the tumor and the right liver. Reconstruction under partial or total liver vascular exclusion is then performed. In this case a prosthetic ePTFE graft was used. (Patient #2, who is alive and well 50 months after the operation). IVC, Inferior vena cava.

grade 1 to 2 sarcomas and adrenal carcinoma were less extended and presented in favorable anatomic locations), the overall 5-year survival of 73% did

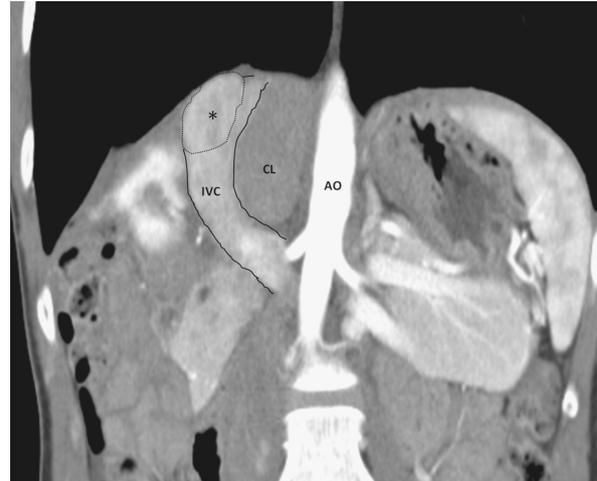


Fig 3. Partial resection of the dorsal side of the IVC. A CT-scan performed 3 months after resection (Patient #4) shows hypertrophy of the caudate lobe that diverts the course of the IVC, which is still patent. The asterisk (*) indicates the venous patch replacing the dorsal portion of the IVC. (AO, Aorta; CL, caudate lobe; IVC, inferior vena cava.)

not differ significantly from that achieved through the current approach (83%).

All repaired and reconstructed IVCs were confirmed patent at Doppler ultrasonography or CT/MRI at the last follow-up visit.

DISCUSSION

In the past decade, with careful patient selection, improved surgical strategies, and effective postoperative care, resection of large hepatic tumors associated with IVC and portal vein reconstruction has been applied increasingly, with low complication rates and positive effects on patient outcomes.^{20,21} In particular, the anterior approach to liver resection associated with the liver hanging maneuver has facilitated the identification of the resection plane through the liver without mobilization of the right lobe, thus avoiding the risk for troublesome bleeding that may originate from attempted dissections of the interface between the tumor and the compressed posterior segments of the right lobe (Fig 4).²² The advantages offered by the anterior approach to expose the retrohepatic IVC have been also described in prospective studies.²³ Hence, the anterior approach has become the standard practice for right hepatectomies in many centers, even when the right diaphragm or adrenal gland is not involved with tumor. The same approach has been described to facilitate left hepatectomies and living-donor right hepatectomy.²⁴⁻²⁶

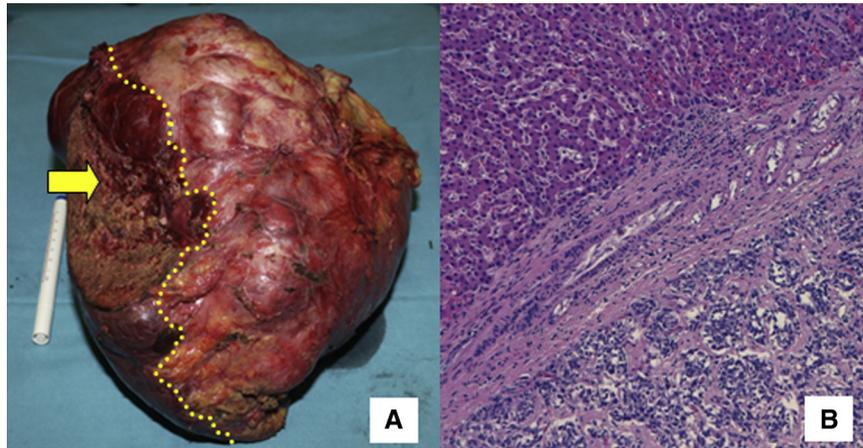


Fig 4. The inseparable tumor-liver interface of large retroperitoneal tumors. In all our cases, a dense, nondissectable adhesion of the tumor with the hepatic posterior segment was present. On gross exam (A), the tumor looks as if it invades the liver (*dotted line*), but often at histology (B), the liver parenchyma may be not invaded and only compressed by the tumor capsule. *Arrow* indicates the margin-free transection plane separating the right liver lobe to be removed en bloc with the tumor.

In our study, this anterior approach to IVC with the implementation of either IVC-preserving or IVC-removing strategies (Figs 1 and 2) is shown to be safe in resecting large retrohepatic tumors (ie, retroperitoneal sarcomas, primary and metastatic right adrenal cancers, and others) en bloc with the right hemiliver. In the experiences at the MD Anderson Cancer Center, this technique has been advocated for resection of large or recurrent tumors of the right upper quadrant involving the liver.¹¹ Our series expands the indications for this technique in extrahepatic neoplasms tightly adherent to the posterior liver segments that would otherwise impede mobilization of the right lobe and isolation of IVC.^{20,27,28} In the presented series, the safety of the en bloc resection of a non-cirrhotic, right hemiliver with the tumor and surrounding structures, including the IVC, has been confirmed. The effectiveness of such an approach in achieving negative margins (R0) for such difficult locations has been verified too.

Mobilization of the liver and retrohepatic tumors should be avoided if vascular control of IVC is not achievable.⁴ In such instances, preparation for total vascular exclusion of the liver during resection should be considered in advance by encircling and securing the suprahepatic and infrahepatic cava²⁰ before the anterior approach to IVC is applied, with the aim of assessing to what extent the tumor is compressing or encasing the vessel. In our experience, a greater than 180-degree circumferential tumor encirclement should indicate the need for partial or total removal of the IVC, with subsequent vein

reconstruction. The appropriateness of such a strategy is supported by the histologic confirmation of tumor involvement in the 3 patients of this series in whom the IVC-removing strategy was adopted.

Surgical decision making about how to approach the posterior hepatic segments and retrohepatic tumors should also consider the thoracoabdominal approach by means of a thoracotomy at the level of the 8th or 9th intercostal space, with division of the diaphragm and costal arch.²⁹⁻³¹ This thoracoabdominal approach provides direct vision of the junction of the right hepatic vein and the IVC, especially when the patient is placed in a semilateral position, and may help in the mobilization of large retrohepatic tumors. Although there are data, mostly from eastern centers, supporting the use of the thoracoabdominal approach for difficult hepatic resections, the use of such technique has not been well described in consecutive series of retrohepatic tumors. Therefore, in the absence of a demonstrated benefit of such alternative over the proposed anteroabdominal approach used in the presented series, surgeons should be aware of both techniques, balancing the risks, mostly respiratory, with the potential benefits for the patient and taking into account the anatomic setting and the dimensions of the tumor to be removed.

In the present study, this complex operation was offered to patients with good performance status who had slowly growing tumors with relatively low metastatic potential and who were undergoing

exploration for curative rather than palliative intent. According to a strategy determined upfront, the patients with adverse anatomic conditions impeding the application of conventional therapies but who still retained high chances of long-term survival with resection were selected for the prospective recruitment.

In particular, the histology and clinical behavior of tumors amenable to such complex resections were important in determining patient outcome; these neoplasms included single tumors with no signs of invasive or metastatic progression and slow-growing tumors in the retroperitoneal space. In the majority of our patients (7 of 10), the presence of a tumor capsule that compressed rather than invaded the IVC, as determined by the absence of any macroscopic IVC invasion or thrombosis, allowed an IVC-preserving strategy through careful separation of the tumor-vein interface. In addition, the tumor capsule also served as a guide to dissection in cases in which tumor masses bulged across the midline (Fig 2). This feature allows to use this technique though its original description advocated the maneuver only for tumors with no adhesions to the IVC.⁸ In the past, patients with high-grade retroperitoneal tumors involving the liver and operated on using conventional operative approaches have generally had dismal prognoses (20% at 5 years in 15 of our patients and 26% to 30% in the literature³²⁻³⁴). Removal of such tumors is of marginal benefit, and that led us to exclude grade 3 and 4 tumors from our protocol.

All but one patient in the current series are alive after a median follow-up of 40 months; this single death occurred in a patient with adrenocortical carcinoma. These long-term outcomes in terms of patient survival appear to justify the resources needed for these operations.

One technical point should be mentioned. Compression of the right liver by large retrohepatic tumors can cause severe bleeding during the phase of parenchymal transection, even when the extent of the resection is limited and the liver hanging maneuver is applied. The main advantages of the anterior approach are the avoidance of the need for right-liver mobilization, superior exposure of IVC, and better exposure for creation of the plane of dissection of the retroperitoneal space. Blood loss related to the anterior approach is controllable because the blood supply comes from the liver and from the retroperitoneal tumor. When retroperitoneal veins and collaterals of the IVC are very dilated, and especially when the IVC-removing strategy is followed, patients may

require massive transfusions and total vascular exclusion of the liver.²¹

In conclusion, the present series has confirmed that, with intensive fluid and transfusion monitoring, the anterior approach to IVC is safe and effective for the resection of large retrohepatic tumors.

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